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Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield. By Capt. W. Noble.

1871, September 24.

ϕ *Capricorni.*

The star disappeared instantaneously at the Moon's dark limb at $22^{h}\,50^{m}\,33^{s}{\cdot}5$ L.S.T. $=$ $10^{h}\,37^{m}\,18^{s}{\cdot}14$ L.M.T. Power 154 adjusted on the star. I did not observe the reappearance. The atmospheric undulation was tremendous.

1871, October 23.

τ^{1} *Aquarii.*

The star disappeared instantaneously at the Moon's dark limb at $22^{h}\,49^{m}\,44^{s}$ L.S.T. $=$ $8^{h}\,42^{m}\,27^{s}{\cdot}5$ L.M.T., and reappeared at her bright limb somewhere about $23^{h}\,23^{m}\,56$ L.S.T. $=$ $9^{h}\,16^{m}\,34^{s}$L.M.T. It was, however, several seconds after this the star was caught at a little distance from the Moon's limb; but the motion of the Moon was, so to speak, so oblique to the parallel of the star's declination, and the definition was so awful from great atmospheric disturbance, that I put this down with much hesitation.

τ^{2} *Aquarii.*

This star, a much more conspicuous one than the previous object, disappeared instantaneously at the Moon's dark limb at $23^{h}\,57^{m}\,27^{s}{\cdot}8$ L.S.T. $=$ $9^{h}\,50^{m}\,0^{s}{\cdot}2$ L.M.T.; and reappeared, pretty sharply, at the bright limb at $1^{h}\,7^{m}\,29^{s}{\cdot}8$ L.S.T. $=$ $10^{h}\,59^{m}\,50^{s}{\cdot}7$ L.M.T.

The Moon's limb was very mountainous and uneven where the star reappeared; and the bubbling and boiling were as bad as, or worse than, ever.

Power 255 adjusted on the stars respectively.

1871, *Nov.* 10.

Self-recording Transit Micrometer. By A. S. Herschel, B.A., F.R.A.S.

Supposing that, in the annexed figure, the motion of a vertical micrometer wire, *a b*, can be adjusted exactly to that of a star in the field of view of a transit instrument, the following automatic arrangement affords the means of chronographically recording the transit of the wire, or of the star, across any moderate number of imaginary fixed vertical wires, at any convenient distances from each other in the field of view. The principal object endeavoured to be realized in the contrivance is that it may be reversible, or equally effective in its action whether the motion of the wire is from right to left, as in observing a star below the pole, or, as in the case of a star's transit above the pole, when the wire moves in the opposite direction. This condition was, however, not the only object kept in view, and believed to be satisfactorily fulfilled in its construction. The principle successfully adopted by Sir Joseph Whitworth to measure extremely small intervals of length (not exceeding the millionth part of an inch),

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by substituting for the ordinary comparisons of divided scales with the length to be measured, by the eye (however well assisted by microscopes), the use of end-contacts only (tested by a peculiar contrivance) with a measuring-screw, while it suggested this arrangement of a self-recording micrometer-frame, seems to be equally well adapted, if the occurrence of contact between two metals can be noted with the same precision by a galvanic current as it can be recognised by mechanical means, to meet the necessary requirements of astronomical exactness.

In Whitworth's measuring instrument, a small metal plate, called a "gravity-piece," whose sides are perfectly parallel and true planes, is inserted between the face of the micrometer-screw and the end opposite to it of the bar whose length is to be measured, these faces being also wrought to parallel and true planes. The support of the gravity-piece between them, by friction, by advancing the screw until the first pressure is just sufficient to prevent it from falling out by its own gravity, affords such an exact test of the degree of mechanical contact existing between the bar and its end-bearings, that when the screw is withdrawn *one millionth part of an inch*, the support is so much loosened that the gravity-piece falls out. The present automatic contrivance may be described as a series of "gravity-pieces" (one for each imaginary transit-wire crossed by the star), whose successive contacts with two bearing-pins in the micrometer frame, and with each other, are made to record the instants of their occurrence by a momentary galvanic current, which will, perhaps, be as brief as that produced by a tap with the finger on a transmitting key, conveying the usual signal to the revolving cylinder of a chronograph. It should be mentioned that the original plan suggested itself to the writer rather as fulfilling the above conditions than from any previous knowledge or trial of experiments on what may be the practical efficiency of the kind of contact levers proposed to be used in it, either to transmit a momentary current of sufficient strength, or to preserve their touching surfaces, and the resulting relative distances between their surfaces unimpaired by frequent use. Difficulties of this kind, although evidently of the first consideration and importance, will yet, it is believed, not present insuperable obstacles to the adoption of some similar mechanical contrivance for transmitting galvanic signals, and for thereby automatically recording transits by the customary chronographic means.

The accompanying figure represents the interior of the micrometer (the front, or eye-plate, having been removed); A B is the micrometer-screw; and B C the wire-frame, to which it gives motion, furnished with horizontal wire, B C, and with a single vertical wire, *a b*. By the motion of the wire-frame the vertical wire, *a b*, is supposed, in the figure, to be carried from right to left, across the field of view, accompanying the image of a star, which it is made constantly to bisect, by means of a proper motion supposed to be imparted to the micrometer-screw, and thence to

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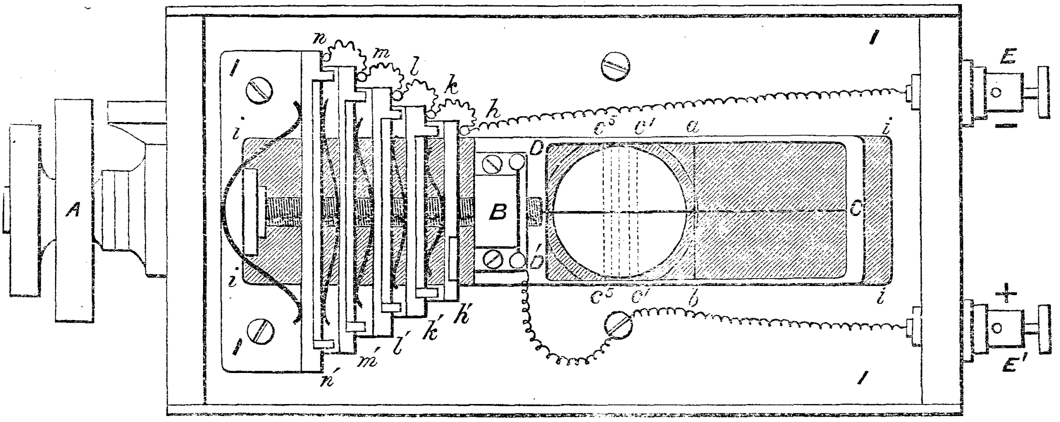
the wire-frame, in the same direction. The dotted lines, $c_1 c_1$, $c_5 c_5$, in the middle of the field of view, represent the imaginary transit wires, or the positions of the movable wire at the instants of its passage across them which it is desired to record chronographically.

The description of the other essential parts of the instrument is as follows:—I I I I is an ivory plate, about an eighth of an inch thick, firmly fixed in the micrometer-box, so as (with the exception of the longitudinal slit, *i i i i*, along its centre) to cover without impeding the motion of the wire-frame and other parts in its interior. In the portion, *i i n n' h h'*, of its surface it contains a recess or depression in its thickness, of the form shown in the figure, to receive the movable and sliding contact-bars, *n n'*, *m m'*, *l l'*, *k k'*, *h h'*, each of which is shown in the figure in its position of rest, supported at its ends against the fixed, step-like bearings in the sides of the recess; and pressed against these supports by slender springs, placed between them, one of which, at the end nearest to the micrometer-screw-head, also presses against the inner side of the recess at that end of the micrometer-box. These bars should be of platinum, about one line in thickness, and held down in their recess by a second plate, or thin cover of ivory, placed over them. They are also provided with a projecting part, along their lower side (not shown in the figure), fitting into the longitudinal slit, *i i i i*, of the principal ivory plate, by which they are guided in their sliding motion when the springs are compressed, and are enabled to return exactly to their proper bearings when the springs are again released. At the points *h*, *k*, *l*, *m*, *n* small platinum pins are inserted in the ivory steps, forming metallic surfaces, upon which the ends of the platinum sliding-bars press, in their position of rest; and these ends are thus all placed in galvanic connection (through the loops of a single insulated wire, *n h* E) with one terminal, E, of the arrangement. The remaining portion of each bar is completely insulated; and galvanic communication between them, through the hair-springs, is avoided by facing the front of each bar, as represented in the figure, with a thin plate of ivory, which is also continued in a



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small tooth or projection at the ends *k′*, *l′*, *m′*, *n′*; while the corresponding projections at the ends *k*, *l*, *m*, *n* are of the same metal as the bars; and are destined to be the only means of metallic contact, and of electrical communication between them. Only a part of the front bar *h h′*, near the end *h′*, is similarly covered with a thin plate of ivory, and it is thus protected from metallic contact, at that point, with one of two projecting pins D, D′, of platinum, inserted in the wire-frame of the micrometer. These pins must be made sufficiently strong and high to press together all the sliding bars towards the screw-end of the micrometer, when the motion of the screw causes the wire frame and the movable wire *a b* to cross the field of view from right to left. The slender extension-springs between the bars are so graduated in strength that the first, which is fastened to the bar *h h′*, *will be completely compressed*, and that bar *will come in contact with the projecting points, k, k′ of the next bar* before the spring attached to the latter bar is affected. The second spring will then be compressed in its turn, without affecting the third, until the second bar touches and presses the third bar from its place, when the third spring will begin to be compressed; and so on in order. Since the pressure of the springs acts, in each case, upon the centre of the bars, it is evident that any greater pressure than this (like that of contact between the bars and the projecting point of the next following bar) acting in the opposite direction, *between the centre and one end of the bar,* will immediately cause that end of the bar to be lifted from its bearing. In this manner the contact of *the pin* D, *and of the ends h, k, l, m, n of the bars* with each other will be simultaneous with the removal *of those ends of the bars* from their bearings, so as to allow, at least, only an inappreciably small interval of time to elapse between the completion of the circuit through D, and the ends of the sliding-bars, from E′ to E, and its interruption at the next instant of time by the separation of the same end of the last bar of the row set in motion from the platinum pin placed there for its support. On the other hand, when the springs are released, by the motion of the screw and of the micrometer wire-frame in the opposite direction, the metallic communication completed between the terminals E E′ at the moment when any bar of the series falls in with its fixed metallic support, is, at the same instant, or at least in the next inappreciably small interval of time, broken by the opening of the bars at that end, produced by the expansion of the next spring in the advancing row.

When a star enters the field of view, and is accompanied across it by the movable wire, starting from the right, as in the figure, the poles E, E′ being connected respectively with a galvanic battery and with a chronographic-recording apparatus; on the arrival of the wire at c_1 c_1, the pin D, coming into contact with the first bar *h h′*, and at the same time removing its end *h* from the platinum bearing on that point, causes a galvanic current of momentary duration to pass from the battery to the recording

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instrument, conveying an impression, like that which is produced by a small tap of the finger on a transmitting key, to th revolving drum.

The wire having next advanced an interval equal to that contained between the bar $h\,h'$ and the projecting metallic part at k of the second bar $k\,k'$, a second current of the same kind will record the instant of contact between the first pair of bars, or the moment of the star's transit over the second imaginary vertical wire. After an interval corresponding to the distance between the second bar and the projecting part at l of the third bar, the moment of contact between this pair of bars will be similarly recorded, and the instant is that at which the star crossed the position of the central or third imaginary transit-wire. Advancing thus until the last pair of bars are made to touch each other, and the moment of the star's transit over the last imaginary wire $c_5\,c_5$ is thereupon recorded, the strongest extension-spring of the series, that acting upon the bar $n\,n'$ will then begin to be compressed, while the movable wire is carried in that direction to the furthest limit of the field of view. In this position, by an exactly reversed series of operations (when a star is observed above the pole, and the wire is driven by the screw in the opposite direction, following its motion), the instrument may be made to record automatically the times of passage of the star, or movable wire, over exactly the same positions of imaginary vertical wires in the field of view as those which it traversed when moving in the previous direction. It is at least important to observe that the *difference* from the same exact positions, thus oppositely obtained, may be expected to depend less upon want of mechanical accuracy in the construction (*durability of surfaces, rigidity of the bars and pins, and immobility of the bearing-points*, being supposed to be practically attainable), than upon the different sensibility of galvanic currents of ordinary strength (arising from the heat which they produce in their passage) to the exact moments of commencement, and interruption of mechanical contact between two surfaces of metal, which are first brought into contact by pressing them together, and are then separated by gradually withdrawing them from each other. With the use of feeble currents, and of a specially delicate recording-apparatus, like that recently exhibited to the British Association at Edinburgh, as introduced by Sir W. Thomson to record the very feeble currents despatched through long submarine cables; the condition of reversibility in its action being apparently fully satisfied, with the exception of a, perhaps needless, complexity, and consequent liability to derangement in its details, which a more ingenious mechanical disposition of its parts would not impossibly remove the remaining conditions of rapid precision in its signals, and of regularly recurring intervals between them appear to be, at least, provisionally, and, although less certainly, yet in the present form of a self-recording transit-micrometer, perhaps not quite inadequately fulfilled.